



# Megaprosthesis Reconstruction of the Proximal Femur following Bone Tumour Resection: When Do We Need the Cup?

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**Purpose:** Reconstruction of the proximal femur after tumour resection can be performed with proximal femoral endopros-theses (PFE). Many studies have reported that bipolar hemiarthroplasty (BHA) reduce the risk of dislocation after oncological resections. However, progressive cotyloiditis which might require acetabular resurfacing (total hip arthroplasty [THA]) has been reported. The aim of this study is to compare the results of BHA and THA after proximal femur resection.

**Materials and Methods:** A total of 104 consecutive patients affected by primary (n=52) and metastatic (n=52) bone tumours were included. Ninety patients underwent BHA and 14 patients underwent THA. Complications were recorded and classified according to the Henderson classification. At final follow-up, patients with the implant in site were functionally evaluated with modified Harris hip score (HHS).

**Results:** The mean follow-up was 50 months (range, 2-171 months). Twenty-four (23.1%) patients developed major complications. Eleven (12.2%) BHA required acetabular resurfacing. Patients affected by primary bone tumours showed an increased risk of THA conversion ( $P=0.042$ ). A reduced risk was observed in patients younger than 35 years ( $P=0.043$ ) and in those older than 65 years ( $P=0.033$ ). Dislocation occurred in four case (3.8%), in particular after THA ( $P=0.021$ ). At final follow-up, 93 patients had the prosthesis in site (80 BHA and 13 THA). Mean postoperative HHS was 70 (range, 30-90).

**Conclusion:** The risk of dislocation is lower for bipolar endoprosthesis compared to THA. However cotyloiditis and acetabular resurfacing might occurred.

**Key Words:** Femur, Hip sarcoma and bone metastasis, Arthroplasty

**Submitted:** January 28, 2021 **1st revision:** March 4, 2021

**Final acceptance:** March 24, 2021

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**INTRODUCTION**

The proximal femur is a relatively common location for primary bone sarcomas and bone metastasis<sup>1</sup>.

Limb salvage is possible in most cases. Reconstruction can be performed with either an allograft prosthesis composite or a proximal femoral endoprosthesis (PFE)<sup>2,3</sup>. In both cases reconstruction can be a total hip arthroplasty (THA) or a bipolar hemiarthroplasty (BHA).

Instability and dislocation are major complications following PFE; however, the reported rate of dislocation is significantly higher with THA compared to BHA<sup>4,5</sup>.

On the other hand, revision from BHA to THA may be required for a considerable number of patients due to pain and limping. Bipolar hemiarthroplasty in PFE can eventually lead to cartilage damage and acetabular erosion as measured by Cannon et al.<sup>1,6</sup>, thus resulting in groin pain and subluxation of the hip.

A few studies<sup>2,3,6-12</sup> have compared the results of THA and BHA in PFE. Most of them suggested that BHA are more stable than THA, with good functional results<sup>5</sup>, even though a considerable number of patients may require a revision from BHA to THA because of painful cotyloiditis<sup>5</sup>.

The aim of this study is to compare the results of BHA and THA in PFE reconstruction following resection in patients affected by primary and secondary bone tumours.

**MATERIALS AND METHODS**

The study was approved by the local ethics committee (approval No. 0003067).

Patients were affected by a proximal femur bone tumour

who underwent reconstruction with a PFE were included. Patients with a non-oncologic diagnosis, if affected by a benign bone tumour or if treated with allograft-prosthetic composite (APC) were excluded. Patients were also excluded if the acetabulum was involved with the tumour.

A total of 104 consecutive patients who underwent PFE for oncologic reasons between January 2005 and December 2017 were identified from the Rizzoli Institute prospectively maintained database (Table 1)<sup>2,6,8-11,13,14</sup>. All patients consented to the use of their clinical information at the time of admission and the complete medical records and images were available for revision.

There were 53 females (51.0%) and 51 males (49.0%), with a mean age at the time of surgery of 57 years (range, 18-89 years). There were no skeletally immature patients.

Fifty-two patients (50.0%) were affected by bone metastasis and 52 patients (50.0%) were affected by a primary bone tumour. Primary tumour diagnosis included 24 high grade osteosarcoma, 21 chondrosarcoma, and seven Ewing sarcoma.

Preoperative evaluation included radiographs and magnetic resonance imaging of the pelvis and the proximal femur and computed tomography (CT) of the lungs.

The use of both chemotherapy (ChT) and radiotherapy (RTE) was decided at the discretion of a multidisciplinary team, which included an orthopaedic surgeon, a medical oncologist, and a radiation oncologist. Fifty-five patients (52.9%) received ChT, according to the histotype. In the primary bone tumours group, 23 out of 52 patients (44.2%) received pre- or pre- plus postoperative ChT, and six patients (11.5%) received only postoperative ChT.

Overall, 21 patients (20.2%) received neoadjuvant RTE.

**Table 1.** Review of the Literature

Study	No. of patients	Reconstruction		Mean follow-up (yr)	Revision for any cause (%)	THA Conversion rate (%)	Dislocation rate
		PFE	APC				
Finstein et al. <sup>10</sup>	62	62 BHA		5	19	None	3 (5%)
Jamshidi et al. <sup>2</sup>	57		29 BHA 28 THA	8.3	3.5	None	10.3% of BHA 7.1% of THA
Donati et al. <sup>9</sup>	25	25 BHA		12	16	8	1 (4%)
Menendez et al. <sup>14</sup>	96	62 BHA 34 THA		1.5	7.3	None	10.4% (6 THA; 4 BHA)
Potter et al. <sup>8</sup>	61	61 BHA		4.6	9.8	1.6	6.6%
Ogilvie et al. <sup>11</sup>	33	21 BHA 12 THA		3	-	6	9% (all THA)
Bernthal et al. <sup>13</sup>	86	86 BHA		5.3	8.6	5.8	4.6%
Drexler et al. <sup>6</sup>	65	65 BHA		9.1	12.3	4.6	3%

PFE: proximal femur modular prosthesis, APC: allograft-prosthetic composite, BHA: bipolar hemiarthroplasty, THA: total hip arthroplasty.

The median radiation dose was 5,200 cGy (range, 3,000-7,000 cGy). Radiotherapy was performed in four out of 52 cases (7.7%) in the primary bone tumours group.

Proximal femur resection was performed with the aim of achieving adequate resection margins in primary bone tumours and oncological local control in metastatic disease.

Ninety patients (86.5%) underwent reconstruction with a BHA, while 14 patients (13.5%) received a THA. Two of these were dual mobility cups. Signs of hip arthritis on preoperative radiographs was the main indication for implant of a THA (Fig. 1).

Proximal femur prosthesis included MRP (Bioimpianti; Peschiera Borromeo, Milan, Italy) in 83 cases (79.8%), GMRS (Stryker, Mahwah, NJ, USA) in 13 cases (12.5%) and megasystem-C (Waldemar Link, Hamburg, Germany) in eight cases (7.7%). All of the 14 implanted cups were



**Fig. 1.** A 61-year-old male affected by high grade osteosarcoma of the proximal femur. After adjuvant chemotherapy the patient was treated with resection and reconstruction with total hip arthroplasty.

uncemented.

After surgery, patients were allowed partial weight-bearing for the first month after surgery.

Postoperatively, patients were followed every three months for the first two years, then every six months up to the fifth year, then once a year up to the tenth year after surgery. Follow-up included clinical examination, pelvis and femur radiographs, and CT of the lungs.

Complications were recorded and classified according to Henderson et al.<sup>15</sup>. Femoral stem loosening was evaluated on standard antero-posterior radiographs of the pelvis. Implant failure was defined as implant removal for any cause other than oncologic reasons (local recurrence).

Patients who required conversion of a BHA to a THA because of severe pain with radiographic signs of cotyloiditis were considered as “acetabular failures” (AF). Patients with the implant in site were functionally evaluated at final follow up using the modified Harris hip score (HHS)<sup>16</sup>.

Patients’ characteristics are presented by frequencies and percentages for categorical variables, mean value and range for continuous variables. The Kaplan–Meier survival analysis was used to estimate acetabular failure-rate. Contingency tables and chi-square test were used for comparison of categorical variables between groups.  $P < 0.05$  were considered significant; statistical analyses were performed using the IBM SPSS Statistics for Windows (ver. 22.0; IBM, Armonk, NY, USA).

## RESULTS

The mean follow-up period was 50 months (range, 2-171 months). In detail, the mean follow-up period of patients affected by primary bone tumour was 55 months (range, 6-175 months). The mean follow-up period among metastatic bone patients was 36 months (range, 2-109 months).

Twenty-four (23.1%) patients developed major complications (Table 2).

Among 90 patients who had a BHA, 11 patients (12.2%) required conversion to THA because of cotyloiditis after a mean of 47 months (range, 28-66 months). A dual mobility THA was implanted in three of these patients.

Kaplan–Maier survival analysis showed an AF rate of 2.2% at three years (95% confidence interval [CI], 1.7-2.7) and 18.1% at five years (95% CI, 14.9-21.3). In particular, patients affected by primary bone tumours showed an increased risk of AF ( $P=0.042$ ). A reduced risk of AF was observed in patients younger than 35 years ( $P=0.043$ ) and in those older than 65 years ( $P=0.033$ ) (Fig. 2, 3).

Hip dislocation (type 1 complication) occurred in four patients (3.8%) and was more frequent in THA than in BHA ( $P=0.021$ ). In detail, two out of 14 patients (14.3%) with THA and two out of 90 patients (2.2%) with BHA developed hip dislocation.

Mean time between first surgery and dislocation was 38 months (range, 25-109 months). All cases were treated with open reduction and ligament advanced reinforcement

system (LARS) positioning. No further dislocation was observed.

Four patients (3.8%) developed aseptic loosening of the stem (type 2 complication) after a mean of 44 months after surgery (range, 40-101 months). No case of cup loosening was observed in the THA group.

Deep infection was observed in seven patients (6.7%) at a mean follow-up of 37 months (range, 2-67 months). Four patients required a staged revision with implant removal and cement spacer. Three of these patients underwent a new PFE after a median of three months (range, 2-4 months), whereas one died before prosthesis reimplantation. The other three cases suffered an early prosthetic joint infection and were successfully treated with debridement and implant retention.

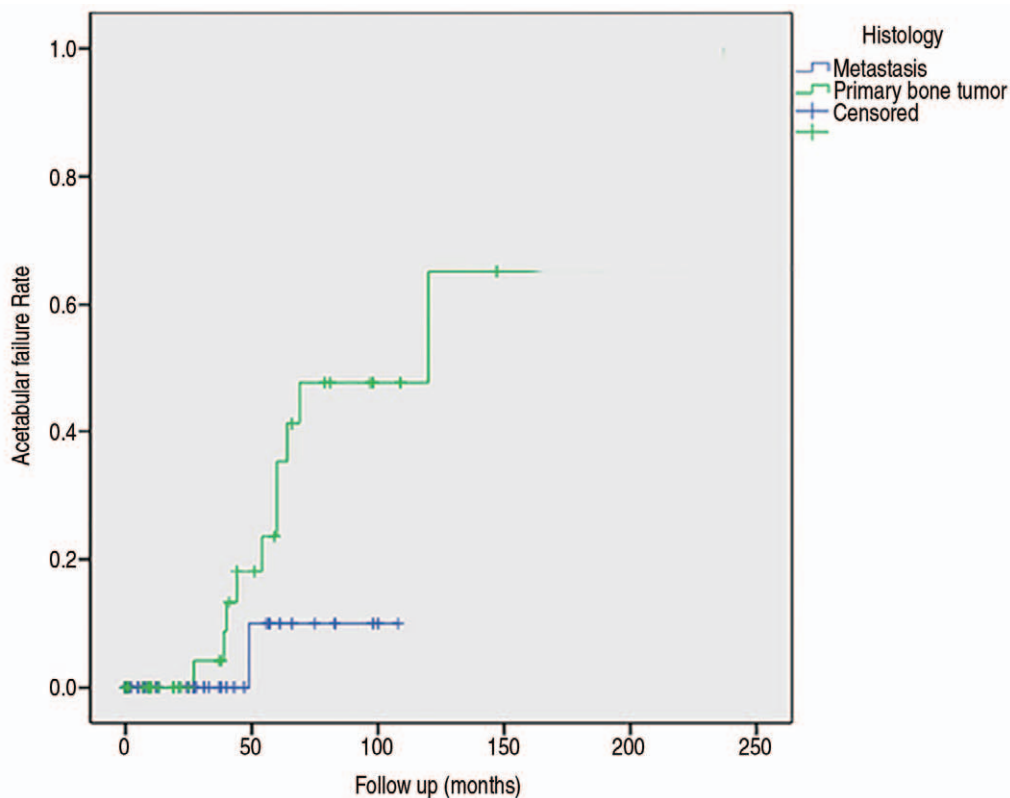
Six patients (5.8%) developed a local recurrence (type 5 complication) after a mean of 26 months (range, 5-69 months). Five patients were primary bone tumour, one was a metastatic patient. One case with dedifferentiated chondrosarcoma required a hindquarter amputation, whereas two patients were treated with recurrence excision. The other three patients died of disease.

At final follow-up, 93 patients had the prosthesis in site (80 BHA and 13 THA) and were therefore available for

**Table 2. Demographic Characteristic**

Characteristic	Value
Age (yr)	57 (18-89)
Sex	
Male	51 (49.0)
Female	53 (51.0)
Primary bone tumour	52 (50.0)
Osteosarcoma	24 (23.1)
Chondrosarcoma	21 (20.2)
Ewing sarcoma	7 (6.7)
Bone metastasis	52 (50.0)
BHA	90 (86.5)
THA	14 (13.5)

Values are presented as mean (range) or number (%).  
BHA: bipolar hemiarthroplasty, THA: total hip arthroplasty.



**Fig. 2.** Kaplan–Meier acetabular failure curve according to disease (primary vs metastasis).

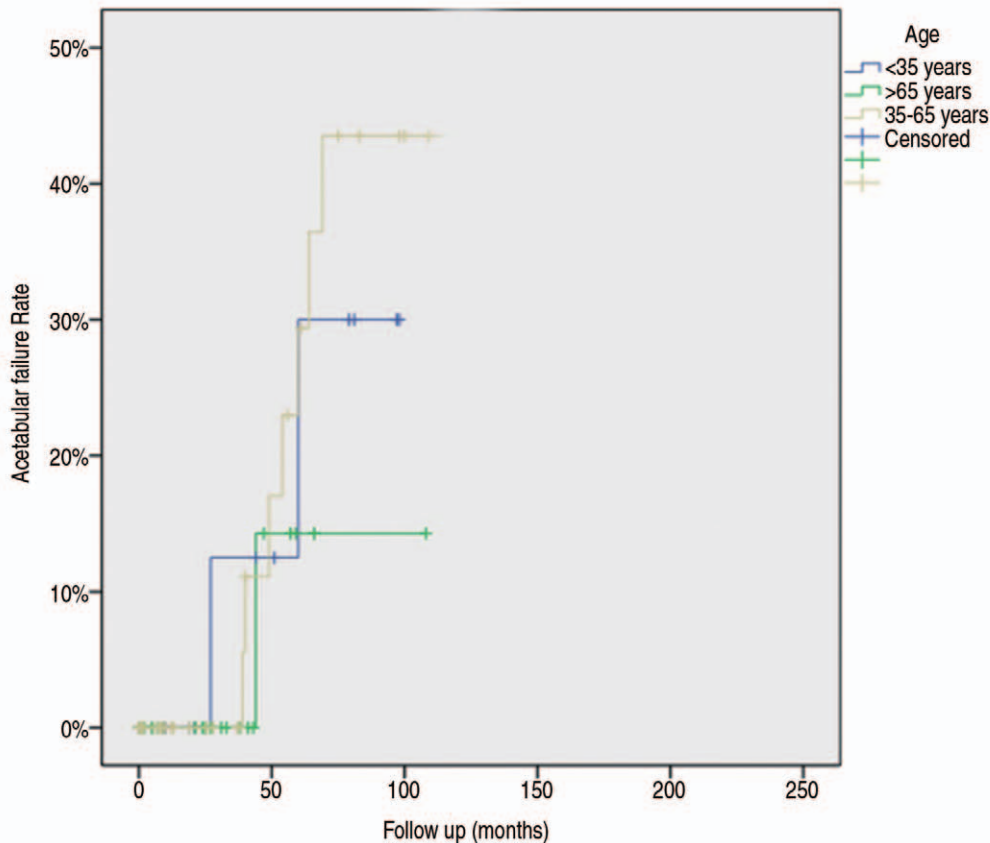


Fig. 3. Kaplan–Meier acetabular failure curve according to patients' age at the time of surgery.

functional evaluation.

At final follow-up, mean HHS was 73 (range, 30-90), with no differences between BHA (mean, 75; range, 45-90) and THA (mean, 75; range, 70-87) ( $P=0.847$ ).

## DISCUSSION

Proximal femur modular prosthesis allows early recovery and good functional results after resections of primary and secondary bone tumours<sup>11</sup>.

Several retrospective studies have reported on the use of either BHA or THA in PFE. However, most of these studies include relatively small and heterogeneous cohorts which included both PFE and APC (Table 3).

In the current series, we observed that 12% of patients with a BHA required conversion to THA, with an estimated risk of acetabular failure of 2.2% at three years and 18.1% at five years. All of these patients suffered hip pain with radiographic signs of cotyloiditis as described by Cannon et al.<sup>11</sup> (Fig. 4).

The acetabular failure rate of the current series is higher compared to previous reports (up to 6%) on BHA PFE

(Table 3), even though long term results might have been influenced by poor prognosis of oncologic patients.

The risk of AF and the need for conversion of BHA to THA was also reported in non-oncologic hip prosthesis. Dalldorf et al.<sup>17</sup> reported a 12% AF rate at long term follow-up, whereas Lee et al.<sup>18</sup> observed groin pain in 20% of young patients with a BHA implanted for osteonecrosis. This group probably fits the most with our oncological cohort, as they considered young patients with a healthy acetabulum.

In our cohort, patients affected by primary bone tumours had an increased risk of AF. This observation might be explained by the worse prognosis and short follow-up of metastatic patients.

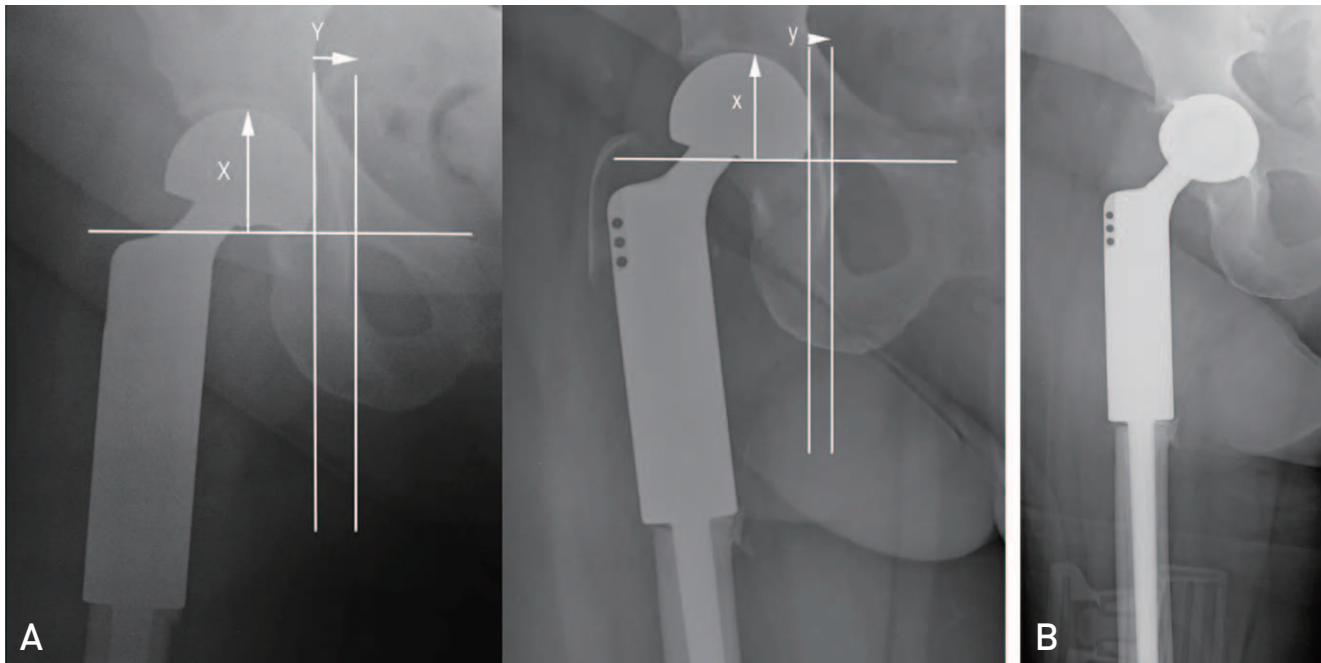
A reduced risk of AF was also observed in patients between 35 and 65 years. We suppose that young patients may have a lower risk of AF because of a higher bone quality. On the other hand, older patients generally have reduced physical activity, thus presumably preserve the acetabulum. In addition, middle age patients can present a primary mild hip arthritis before tumour surgery, that can evolve or accelerate the degenerative process after BHA<sup>5,17,18</sup>. Thus, we sug-

**Table 3.** Complications of the Study Population

	Cotyloiditis	Hip dislocation	Aseptic loosening	Deep infection	Local recurrence
BHA (n=90)	11 (12.2)	2 (2.2)	4 (4.4)	6 (6.7)	4 (4.4)
THA (n=14)	-	2 (14.3)	-	1 (7.1)	2 (14.3)

Values are presented as number (%).

BHA: bipolar hemiarthroplasty, THA: total hip arthroplasty.



**Fig. 4.** (A) A 71-year-old female affected by proximal femur chondrosarcoma. After adjuvant chemotherapy the patient was treated with resection and reconstruction with endoprosthesis. On the left side the postoperative hip x-ray. On the right, the x-ray after 61-month follow-up, showing medial and superior migration as described by Cannon et al.<sup>11</sup>. (B) X-ray showing the acetabular conversion using a porous cup.

gest a careful evaluation of preoperative x-rays in order to select patients with signs of arthritis.

Despite no risk of AF, the downside of THA is a higher dislocation which can negatively influence functional outcome in PFE. Prosthesis dislocation is a major complication in PFE (range, 1% to 37%)<sup>7,11,12,19</sup>. Among risk factors for dislocation in PFE, the implant of a cup appears to be the most significant factor<sup>11</sup>, while length of resection, capsular repair, and abductor reattachment appear unrelated<sup>11,18,19</sup>. In the current series, we report a 3.8% dislocation rate, with a significantly higher risk for THA with respect to BHA. This is lower than data reported in the literature (range, 4.6% to 10.4%).

Several series<sup>7,11,14,20</sup> have reported that bipolar endoprosthesis reduced hip dislocation after oncological PFE. This is in contrast with non-oncological patients where THA offers more stability than standard endoprosthesis<sup>21</sup>.

In case of standard THA, dual mobility cups can help in reducing the risk of dislocation<sup>22</sup>, particularly in patients with neuromuscular diseases<sup>23</sup>. In the current series none of the dual mobility THA cases (neither in primary nor in revision cases) underwent dislocation. Therefore, even though no data regarding these implants are reported in the literature, dual mobility cups might be helpful in reducing dislocation rate when a THA is required in PFE.

A few limitations must be acknowledged. First, the study was retrospective and, therefore, it was subject to inherent limitations and biases. The technique of reconstruction was not randomized, and the preference of the surgeon may have contributed to a selection bias. However, THA was generally chosen as the first implant in case of radiographic signs of hip arthritis. In addition, there were many potentially uncontrolled variables, including the amount of soft tissue excision, characteristics of fixation, the effects and

subjective response of different adjuvant therapies.

In addition, the relatively short term follow-up, partially due to the prognosis of proximal femur sarcoma, may influence our observations about young patients.

## CONCLUSION

Bipolar endoprosthesis has a reduced risk of dislocation compared to total hip prosthesis in reconstructions with proximal femur modular prosthesis. However, the subgroup of patients between 35 and 65 years of age have an increased risk of cotyloiditis and consequent need for an acetabular cup. Reconstruction with a THA should be considered in these subgroups of patients. Further larger series are needed to confirm this observation.

## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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